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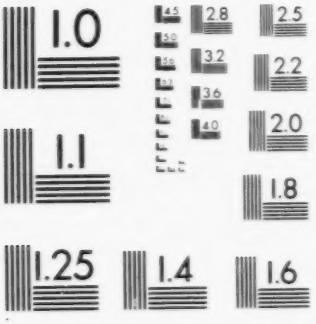

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REPORT FROM THE TASK GROUP ON AQUACULTURE

JUNE 28, 1988

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ACKNOWLEDGEMENTS

In May 1987 a Task Group on Aquaculture was established to identify and prioritize key technical strengths and constraints, prioritize opportunities and corrective measures and determine appropriate means, directions and levels of public sector support for development of the industry. With funding provided under the Canada/New Brunswick Subsidiary Agreement on Industrial Innovation and Technology Development, the Task Group was formed to bring together key leaders from industry, institutions and government. During the course of its deliberations input was received from guest speakers, industry associations and research centres which has proven valuable in the development of this report. We wish to thank the many individuals and institutions for their participation.

1. PREFACE

Programs for Research and Development ideally have the best success when they are established due to a real need rather than a perceived need. Perception, if it has one fault, is the inability to utilize both financial and human resources with the maximum efficiency.

Unfortunately our industry is very young, not only in New Brunswick, but also in the national sense. We are, to some degree, crystal ball gazing and this should be kept in mind when reading this report.

These are exciting times for aquaculture in New Brunswick, and the opportunities are many. This Province has in its grasp the opportunity to be a world leader in aquaculture. We must now combine and focus the scientific skills of our region, which are second to none, with the governments' regulatory personnel and the able private sector if we are to produce the best recipe for success.

The most recent crisis in the shellfish industry, particularly molluscs, solidifies the urgent need for short and long-term research and development. To maximize the return from the research and development, it should be directed by a combined bureaucratic, educational, and private sector committee.

We are fortunate in New Brunswick to have very dedicated people willing to devote long hours and make the mistakes necessary to advance our industry. The growing pains have been, are, and will be many, and often times, through poor communications and lack of understanding, we have been our own worst enemy. I believe this is now changing for the better and this Task Group, if it achieves nothing else, has at least increased the awareness of aquaculture to the Province and will provide a start to educating the various sectors to its potential for growth and prosperity.

Brian Rogers
Chairman
Task Group on Aquaculture

2. EXECUTIVE SUMMARY

Aquaculture in New Brunswick is coming of age. Finally, finfish and shellfish farming is beginning to move beyond the pioneering stages. This is mainly due to the fact that our knowledge of these industries has increased to the point where we can speak with confidence regarding opportunities and investment.

This Task Group has established three facts:

1. New Brunswick can become a world class player in global aquaculture.

2. New Brunswick has the technical facilities and human resources to support this aquaculture industry.

3. The Government of New Brunswick must support both morally and financially, research and development specifically for the aquaculture industry.

The mandate of this group was to identify from the industry perspective opportunities for research and development to enhance the growth and future success of the industry.

Our meetings over the past eight months have concluded the following:

Finfish:

The #1 threat to the farmers is disease and we strongly recommend long-term and short-term research programs to increase our control over and knowledge of bacterial, viral and parasitological disease problems.

High priority for research and development has also been recognized in the areas of fish feed and nutrition, broodstock and genetics, equipment engineering design and environmental monitoring. With an eye to the future the Task Group recommends the start of basic research on new commercially valuable finfish species.

From a commercial point of view the salmon farming industry has proven its viability and the requirement now is for extensive research and development to support its future growth.

Shellfish:

The shellfish aquaculture industry is still very much in the infant stage. In common with the finfish sector is the immediate need for research and development in the areas of disease, nutrition, environmental monitoring, engineering design and new species.

However, the main need of the shellfish producers and researchers is the establishment of a shellfish hatchery. The Task Group recognizes this need and recommends it be reviewed. Management of such a facility should be with the combined input of the industry, research and government.

General:

The Task Group identified several opportunities which would benefit aquaculture for the province in general. These include the establishment of a professional generic marketing campaign to promote New Brunswick aquaculture products.

As well, more can be done to encourage greater emphasis on education and training to guarantee a future supply of aquaculturists.

The establishment of an extension service similar to the agricultural and forestry sectors would provide enormous immediate benefits to the development of the industry.

Finally, and by no means of least importance, the Task Group recognized the very positive benefits of this group meeting for the past eight months. It has done much to improve and increase the communications of all sectors involved in the aquaculture business in New Brunswick. We strongly recommend the establishment of an Aquaculture Council to advise industry, government and research and development interests in the future development of aquaculture in New Brunswick.

3. INTRODUCTION

Aquaculture, the care, culture or husbandry of aquatic fauna and flora is a growth industry with a great potential for expansion. The current industry includes commercial culture of oysters, mussels, and salmonids and it is this fauna on which we have concentrated. There are substantial research and development possibilities in New Brunswick with centres of expertise in St. Andrews, Fredericton, Saint John, Shippegan, Moncton and Caraquet.

Research and development should be market driven. There are excellent opportunities for new research and development initiatives which should be built upon existing areas of activity, and diversification of the existing industry to include additional species (e.g. Arctic char, lobster, scallop, cod, halibut); bio engineering (growth stimulation, genetic engineering); life-support systems and cage design; and the development of cost effective strategies to cope with low water temperature environments. Universities have a capacity to contribute to a number of these initiatives and should become more involved in aquaculture related research and development.

There is an opportunity to develop and apply a systems approach to the aquaculture industry. Improvements are required in the exchange of technological information and ideas at the local, national, and international levels (such as specialized workshops) and the development of better extension services in the areas of engineering, nutrition, disease, husbandry, and enterprise management.

The Canada/New Brunswick Subsidiary Agreement on Industrial Innovation and Technology Development is an agreement which is welcomed by the industry. We do hope that every consideration will be given to the aquaculture industry so that sub-agreement funds will be ear-marked for aquaculture. We are very optimistic that any support will enhance the industry greatly.

4. HISTORY

4.1 FINFISH

For New Brunswick, the commercial culture of Atlantic salmon in marine cages began in 1978 at Lord's Cove, Deer Island as a joint initiative of New Brunswick Department of Fisheries, Fisheries and Oceans Canada, and private industry.

Charlotte County has been the sole New Brunswick location where Atlantic salmon cage culture could take place, but even there, culture sites have had to be selected with a good deal of caution to protect against loss and mortalities from various environmental influences.

A "Salmonid Marine Cage Culture Development Program" has been operating for the past four years, funded initially by New Brunswick Department of Fisheries and Aquaculture and subsequently under the Canada/New Brunswick Fisheries Development Sub-Agreement.

Each 'standard' octagonal wooden cage contained 2,500 fish. At well-run operations, mortalities have been held as low as 3-5 percent. Atlantic salmon average ten pounds in weight at harvest time, with several operations producing fish as large as 16-21 pounds in the 18 month growing period.

Fish health extension services and complementary aquaculture training workshops provided by New Brunswick Department of Fisheries and Aquaculture have contributed to the development of the industry.

The Loan Guarantee Program of New Brunswick Department of Fisheries and Aquaculture has enabled industry development to be placed upon a much sounder economic footing by encouraging the banking community to become involved. This has resulted in establishment of the desired blend of both large and medium-sized operations.

4.2 SHELLFISH

Development of the cultured mussel industry in New Brunswick has been underway since 1977 when the first demonstration projects were carried out in the southeast area of the province. Through the research and development efforts of Research and Productivity Council, the New Brunswick Department of Fisheries and

Aquaculture, the Department of Fisheries and Oceans, as well as private entrepreneurs, the industry has now gained a foothold in the eastern region of the province, and more latterly in the Bay of Fundy.

Farming of the Atlantic or Eastern oyster is without doubt one of Canada's earliest form of aquaculture. Traditionally, oysters were farmed using birch saplings to collect the larvae (spat), after which the bark was removed in the autumn and placed on beds where oysters were grown to market size. This practice has remained essentially unchanged, except that mere modern, treated plastic materials have been substituted for the spat collection phase of the operation. In addition, a few growers are using various forms of off-bottom growing techniques to take advantage of accelerated growth rates possible when oysters are suspended in the water column.

5. CURRENT STATUS AND FUTURE PROJECTIONS

5.1 FINFISH

At present, there are 32 individuals or companies, at various stages of development, growing Atlantic salmon at marine cage sites in the West Isles region of Charlotte County. Two additional growers are culturing rainbow trout in marine cages.

Although marine culture sites have been established throughout the southwest Bay of Fundy region, there are two main centres of salmonid culture activity. One is in the Lime Kiln Bay/Back Bay/Bliss Harbour area, while the other is in the Campobello, Grand Manan and Deer Island area.

At existing 1987 prices of $6.25 per pound, a ten pound Atlantic salmon is worth $62.50. Since potential net profits are exceptionally good, this has created a flood of requests both for marine grow-out sites and for freshwater commercial hatchery sites.

Significant benefits to the provincial economy have been derived in terms of direct sales and permanent jobs created. Salmonid production values have doubled in each of the past three years with approximately $8 million worth of Atlantic salmon sold during the 1986 marketing season. Sufficient smolt have been placed in marine cages to anticipate sales for the 1987 marketing season in excess of $22 million and $34.8 million of direct sales in 1988.

TABLE 1

ANTICIPATED VALUE OF MARKET SIZE CULTURED ATLANTIC SALMON

Year	# Smolt	# Market Fish*	Market Fish Tons**	Anticipated Market Fish *** Value ($Million)
1986	420,000	200,000	726	8.0
1987	800,000	365,000	1656	22.8
1988	1,600,000	696,000	3158	34.8
1989	2,000,000	1,392,000	6316	69.6
1990	2,400,000	1,740,000	7895	87.0
1991		2,088,000	9474	104.2

The above dollar value represents monies paid to the farmer.

* An 87% survival rate from smolt stage to market fish has been assumed.

** An average market weight of 8 lbs. per Atlantic salmon has been assumed in 1986 and 10 lbs. for 1987-91.

*** An average market price of $5 per lb. has been assumed for Atlantic salmon in 1986 and 1988-91.

To facilitate comparison of the above figures with production values of other industries in 1986, the following is presented:

TABLE 2

ANNUAL VALUES (1986) OF
SOME NEW BRUNSWICK INDUSTRIES

Crab Fishery	$23,840,000
Lobster Fishery	33,920,000
Herring Fishery	13,720,000
Groundfish Fishery	10,100,000
Scallop Fishery	5,820,000
Clam Fishery	3,600,000
Other Fishery	7,000,000
Dairy	53,400,000
Potatoes	43,100,000
Poultry	23,900,000
Cattle	22,900,000
Hogs	22,600,000

* Prices to the producer.

As can be seen from the numbers above, the farming of Atlantic salmon is fast becoming a major resource-based industry, one which is expected to grow very rapidly in the next three to five years.

A wide variety of spin-off benefits and permanent employment is being created within New Brunswick as a direct result of establishment of the Atlantic salmon culture industry. Opportunities are now being realized in service industries and secondary manufacturing. These include feed manufacturing plants, netting and gear suppliers, sawmills, metal fabrication shops, cement plants, packaging plants, transportation, therapeutic drug suppliers, and a variety of general industries not related to aquaculture.

Fish feed requirements in 1987 are estimated at a value of $5.32 million, up from $2.86 million in 1986. Fish and fish by-products constitute the bulk of the fish feed rations. Significant impact will begin to show in the primary and secondary components of the traditional fishery in all parts of New Brunswick. Fish feed requirements will grow rapidly. For 1988, fish feed sales could exceed $10.37 million.

TABLE 3
ANTICIPATED VALUE OF ATLANTIC SALMON SMOLT

Year	# Smolt *	Anticipated Smolt Value ($ Million) **
1986	420,000	1.36
1987	800,000	2.60
1988	1,600,000	5.20
1989	2,000,000	6.50
1990	2,400,000	7.80

* Includes smolt grow-out In N.B. waters only.
** Figures based upon an average price of $3.25 per smolt.

TABLE 4
HATCHERY FEED MARKET: SALMON
DRY DIET FISH FEED REQUIREMENTS
(FRESHWATER PHASE)

Year	# Smolt	Feed * (Tons)	Value **
1986	420,000	42.3	$ 50,760
1987	800,000	80.7	96,840
1988	1,600,000	161.3	193,560
1989	2,000,000	291.7	350,040
1990	2,400,000	242.0	290,400

* Figures based upon nine 50 g smolt per pound and a feed conversion ratio of 2:1.
** Figures based upon dry feed cost of $1200 per ton.

TABLE 5
MARINE FEED MARKET: SALMON
MOIST DIET FISH FEED REQUIREMENTS
(MARINE PHASE)

Year	# Smolt	Feed * (Tons)	# Market Fish	Feed** (Tons)	Tons Total Feed	*** $ Value (Million)
1986	420,000	1,302	200,000	1,520	2,822	2.82
1987	800,000	2,480	365,000	2,774	5,254	5.25
1988	1,600,000	4,960	696,000	5,290	10,250	10.25
1989	2,000,000	6,200	1,392,000	10,580	16,780	16.78
1990	2,400,000	7,440	1,740,000	13,224	20,664	20.66

* Feed requirements calculated using 310 tons moist feed per 100,000 smolt (feed conversion ratio 2.3:1) 3 lb. weight after year #1..

** Feed requirements calculated using 760 tons moist feed per 100,000 Atlantic salmon market fish (feed conversion ratio of 1.7:1). 10 lb. weight, at market weight.

*** Based upon moist feed cost of $1,000 per ton.

The New Brunswick aquaculture industry currently has available an abundant supply of top-quality fish food ingredients. The rapid growth of both the local and worldwide industry will provide increased price and availability pressure on these feed ingredients.

With time, New Brunswick's currently favoured feed manufacturing position will be affected by competition for feed ingredients on an international level.

5.1.1 Employment Related to Finfish Aquaculture

The development of the salmonid aquaculture industry in the lower Bay of Fundy area has had a major employment impact on New Brunswick and in particular on the Charlotte County area. With product sales exceeding $22 million in the 1987 market year, it is estimated that in excess of 1,000 person years of employment have been and will be created by this industry in calendar years 1987/88. This number is expected to increase significantly with the projected expansion of the industry.

The employment opportunities are provided in a range of activity areas, some of which follow:

a) Salmon and Trout Hatcheries
b) Salmon and Trout Cage Operations
c) Administrative and Processing Support
d) Research Laboratories
e) Training Institutions
f) Government Offices in Support of Aquaculture
g) Suppliers to the Industry of equipment and services.

5.2 SHELLFISH

5.2.1 Mussels

Commercial shellfish culture (American oysters and Blue mussels) is primarily carried out in the northeast and southeast coastal areas of the province. Production volumes and value of sales are small, difficult to obtain, and generally reflect a combination of harvested wild stock and a much smaller quantity of cultured stock. It is anticipated that cultured shellfish production values will exceed $1 million by the early 1990's.

When contrasted with the size of the mussel industry in Prince Edward Island and Nova Scotia, New Brunswick's industry is markedly smaller. Recent figures suggest that annual production of cultured mussels in New Brunswick in 1987 was in the order of 30,000 lbs (13,636 kg) with an attendant value of $20,000.

Given the quality of the mussel growing areas in New Brunswick, which compare favorably with those in Prince Edward Island and Nova Scotia, site suitability cannot be regarded as a serious constraint to further expansion of the industry. However, the flow of private investment capital into expansion of the industry has not proceeded at the rate initially anticipated.

At present, the New Brunswick cultured mussel industry consists of four pilot projects, one semi-commercial project, and one commercial project in the northeast; seven pilot projects, one semi-commercial project and one commercial project in the southeast; and two pilot projects, and two semi-commercial projects in the southwest Fundy region.

The development programs implemented by the Department of Fisheries and Oceans and the New Brunswick Department of Fisheries and Aquaculture, with additional technical assistance provided by the National Research Council Industrial Research Assistance Program and the Research and Productivity Council have all contributed to the current state of the development of the industry. In the spring of1987, a mussel growers' association was organized in the Gulf region of the province to act as a forum for New Brunswick growers to consider industry related problems.

The situation involving toxicity in shellfish on Prince Edward Island and in Caraquet Bay, New Brunswick has undoubtedly imposed a temporary constraint on the industry. However, as in the Bay of Fundy which contends with annual periods of toxicity in shellfish, this is regarded by industry as yet another problem which must be managed. Although there has been a decline in markets because of this recent event, this is regarded as a temporary set-back which will be overcome with time and the recently announced marketing assistance program to be implemented by Dept. Fisheries and Oceans and the industry.

The general success of the industry in other Maritime Provinces, Quebec, and in the State of Maine, are all factors which have stimulated New Brunswick shellfish farmers to consider investment in the industry.

At the present pace of development, the New Brunswick Department of Fisheries and Aquaculture projects that the cultured mussel industry should have sales of $100,000 by the early 1990s.

5.2.2 Atlantic Oysters

The main producing areas for the Atlantic oyster in Canada are concentrated in the southern Gulf of St.Lawrence as illustrated in Figure 1. Attempts have been made to introduce oysters to coastal waters of Newfoundland, Québec, and to the Bay of Fundy; however, none of these attempts have met with success.

The oyster industry in New Brunswick, as along the whole of the eastern coast of North America, has not prospered in recent years despite apparent increases in landings. This appears to be a result of a combination of social, economic and technological problems being experienced in the industry. In New Brunswick, an oyster requires upwards of seven years to reach market size utilizing traditional bottom growing techniques.

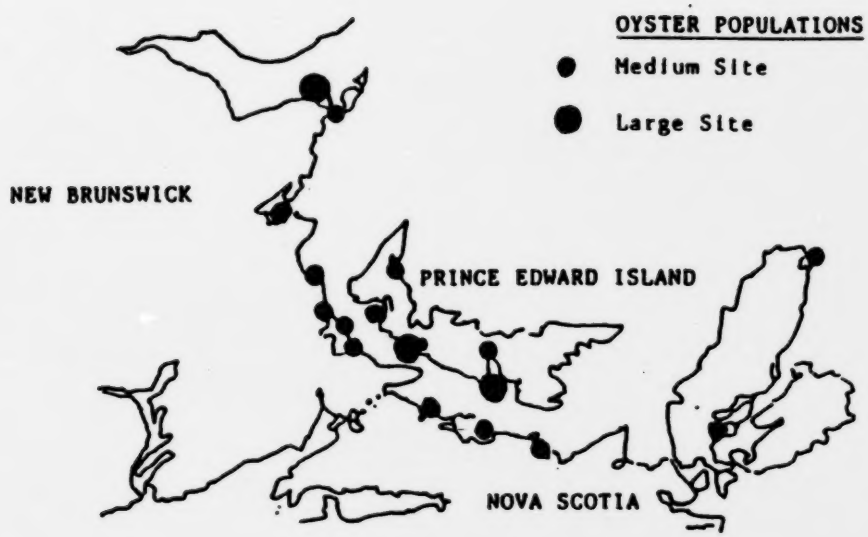

FIGURE 1. Oyster Growing Areas in Eastern Canada

Accordingly, investment in an industry for which returns require seven years to be realized has not been particularly attractive to most financial lending institutions.

It would appear that this view is now beginning to fade as the demand for oysters increases, the value of the seafood industry is being recognized, and the financial returns appear to be more favorable. By way of example, the price received for oysters in 1987 was double that received in the previous year, and indications are that the pricing structure will remain strong, at least over the next few years. However, to take advantage of these opportunities, there is now, more than ever, a strong industry need for access to technology which will shorten the time required to raise a market size oyster. Moreover, technology is also required which will allow growers to reduce the labour intensity of their operations, increase their spat collection efficiency, reduce losses due to predators and disease, and generally contribute to the development of a more economically attractive and viable industry.

Currently, production data are not comprehensive enough to distinguish between oysters harvested from culture operations and those fished from public beds. However, as a guide to combined production, Table 6 illustrates the quantities of cultured and wild stock oysters landed in the Maritimes.

TABLE 6
OYSTER LANDINGS IN THE MARITIME PROVINCES 1970 - 1985

YEAR	Quantity (Pounds)		
	Nova Scotia	New Brunswick	P.E.I.
1971	40,600	463,000	1,810,700
1972	61,200	639,000	993,700
1973	56,800	695,500	1,301,900
1974	46,100	932,900	1,333,700
1975	35,800	1,439,900	1,612,800
1976	113,400	871,800	1,558,800
1977	119,700	753,800	1,847,800
1978	142,000	848,700	2,318,900
1979	157,545	793,000	2,484,900
1980	189,630	1,258,000	2,361,707
1981	224,910	1,099,600	2,686,275
1982	108,045	1,300,000	1,917,585
1983	123,480	1,400,000	2,434,185
1984	189,630	1,583,190	3,385,318
1985	44,100	1,600,000	3,403,240

At a price of approximately 70 per pound, the oyster fishery in New Brunswick is currently valued at about $1.1 million annually.

The industry in eastern Canada is directed primarily at the half-shell trade, with oysters being shipped to Québec and Ontario, as well as to the eastern seaboard of the United States. Some product is even flown to the west coast of Canada, although this is done on a limited scale. The value of the oyster is judged on the basis of the shape of its shell as opposed to the quality of the meat contained therein. Therefore, it is important that young oysters be provided with a hard growing surface, either natural or artificial, to avoid developing low value elongated shells which are typical of animals grown in soft sediments.

Since the early 1970s, development efforts have been concentrated on private sector leases, as opposed to public beds. In 1985, landings (wild and cultivated oysters) offered by private growers totalled some 800,000 lbs. This sector includes 482 leaseholders farming 4,080 acres of leased bottom at 18 sites along the Gulf of St. Lawrence coast. However, according to reports from the growers themselves, only a relatively small proportion of these sites are actively farmed. This confirms the widely held belief that many leaseholders are paying their annual lease fees without devoting any more than the minimum effort required to justify holding their lease. It is estimated that up to 75 percent of all New Brunswick landings are derived from harvests in only five areas: Caraquet Bay, Miscou, Miramichi Bay, Shippegan, and Bouctouche Bay.

In the past, leasehold growers in the northeast of the province depended on seed gathered from a few productive sites which could be reached at low tide. Growers in the southeast have almost exclusively depended on seed collected on a variety of artificial surfaces. It was recently recognized that there is a strong need for an accelerated oyster seed production program to supply growers with the quantities of seed required to make their operations individually more viable and to increase the economic value of the industry as a whole. To this end, a development plan was formulated in 1979 with the principal aim of developing the technology to increase seed production for leaseholders. This was to be done by promoting the establishment of a small group of producers who would specialize in seed production and thus alleviate at least one industry problem, that is the lack of natural seed production in many of the province's growing areas.

With the increasing contributions by these seed producing companies as well as by individual growers themselves, it is anticipated that oyster production in New Brunswick should continue to increase. The private sector production potential has been estimated to be in the order of approximately 60 million pounds. Using a very conservative approach, production potential from the existing 4,080 acres is estimated at 18 million pounds of the 60 million pound potential. This is based on an average yield of 27,000 lbs per acre (12 tons) and a six-year rotation of the4,080 acres under cultivation.

5.2.3 Other Shellfish Species

To-date there are no other shellfish species being cultured on a commercial basis. However, with the increase in demand for high quality seafood, and with the growing awareness of the need for advances in culture technology, there are strong indications that species such as the European oyster and the giant sea scallop offer real potential for cultivation in the Bay of Fundy.

With respect to the European oyster, which is being successfully cultured commercially in Nova Scotia, preliminary research undertaken in the southwest Bay of Fundy by Research and Productivity Council, Fundy Isles Marine Ltd., and the New Brunswick Department of Fisheries and Aquaculture has shown that, using hatchery reared seed, it is possible to produce a market size oyster in three to four years.

The giant sea scallop also affords a commercial culture opportunity, especially now in view of the concerns being expressed over the dwindling wild stocks on George's Bank and elsewhere in the region. The Department of Fisheries and Oceans has already initiated some investigative work directed towards gaining a better understanding of the requirements for cultivating oysters in captivity. It is reasonable to project that within the next few years this information will be utilized by the private sector in establishing at least a pilot scale growing operation.

Interest has also been expressed recently by the private sector in establishing a softshell clam hatchery based on one of the models currently being used in Maine. The objective in this case is a culture based fishery operation in which seed produced in a hatchery would be "planted" in areas which have been over-harvested.

While all of the above hold out real potential for development, none can proceed beyond very rudimentary stages since New Brunswick has no shellfish hatchery in which to undertake the necessary research and development, and which could also act as a source of seed for private sector operators.

6. FACILITIES INVENTORY

There are at present a number of research and technological institutions in New Brunswick that have ongoing programs in aquaculture science and technology. These include the several research and development organizations in Charlotte County; in St. Andrews, the aquaculture research programs at the DFO Biological Station, the Huntsman Marine Science Centre (HMSC), and the Atlantic Salmon Federation (ASF) are well established. Near St. George, on Lime Kiln Bay, a Salmonid Demonstration and Development Farm has recently been established. In addition, both Sea Farm and Connors Bros. Ltd., Aquaculture Division, are actively involved in research and development activities. The New Brunswick Community College, St. Andrews campus, and the HMSC, with support from the Canadian Employment and Immigration Commission (CEIC), have provided an Aquaculture Technician Training Program which has been in operation since 1978.

Other centres of aquaculture research and development in New Brunswick include the Fredericton area with the Biology Department of the University of New Brunswick; the Food, Fisheries and Aquaculture Department of the Research and Productivity Council; as well as the aquaculture support programs of Provincial Departments of Fisheries and Aquaculture, Commerce and Technology, etc. In Moncton, DFO and the Université de Moncton provide support for aquaculture research and development. In Shippegan, there are research aquarium facilities available, however, aquaculture research appears to be limited at present.

The current strengths of the aquaculture sector in New Brunswick include the following:

a) The sector is in a rapid growth phase.
b) There is a strong base of existing research and technological expertise that can be further developed and brought to bear on the problems.
c) The investment climate (and opportunities) for aquaculture (especially salmonids) is positive and improving.

Clearly, New Brunswick has a very active research and development community which has made significant contributions to the advance of aquaculture in the province.

However, it is also clear that New Brunswick researchers seriously lack the support and funding to permit them to adequately meet the demands imposed by a very dynamic industry.

7. AQUACULTURE RESEARCH AND DEVELOPMENT IN NEW BRUNSWICK TO-DATE

The intention of this review is not to provide a detailed literature review of current and past aquaculture research and development in New Brunswick. Rather it is intended to provide the reader with an overview of the kinds of research and development activities which have been undertaken in the Province over the last several years.

Although most New Brunswickers are perhaps more familiar with recent developments, such as those which have been taking place in the culture salmonid industry, aquaculture research and development in New Brunswick has, in reality, been ongoing for more than 30 years and has involved several species.

For the purposes of this review research and development activities will be considered by species or species groups:

7.1 FINFISH

It is probably not an overstatement to say that by comparison there has been considerably more research and development devoted to the salmonid fishes of New Brunswick than to any other cultured species or species groups. As well, individuals are probably more familiar with salmonid culture, than with that described for the species which follow.

It is also true to say that a very significant proportion of the salmonid research and development was undertaken prior to the comparatively recent advent of commercial salmon culture in southwestern New Brunswick. However, the firm foundations established by this wealth of early research, must also be acknowledged as being responsible, to a large degree, for the success which the industry enjoys today.

To adequately acknowledge (let alone describe) all these early salmonid research efforts is clearly beyond the scope of this brief review. Nevertheless, in assessing the current status of aquaculture research and development and considering its needs for the future, the work of research scientists, engineers, biologists and technicians in Federal and Provincial government departments, in universities, and entrepreneurs in the private sector, must be recognized as having played the dominant role in making possible a commercial salmonid industry. Recognition should also be given to the recreational fishing sector, whose financial and moral support also contributed in a large way to maintaining the high profile of salmonid fishes.

Specific mention should be made too, of the ongoing salmonid research programme at the St. Andrews Biological Station and more latterly of the work undertaken at the Atlantic Salmon Research Centre in Chamcook. In addition the work undertaken in operating the Department of Fisheries and Oceans fish hatcheries has also been instrumental in developing a knowledge base for fish husbandry and nutrition. The many programmes undertaken by the New Brunswick Government and the research work of the University of New Brunswick, Biology Department all contributed to the strength of the information base which was fundamental to the development of commercial prospects. What may be described as the modern era of salmonid aquaculture research probably began with the joint ventures between Marine Research Associates and the Department of Fisheries and Oceans, who established the initial cage rearing sites on Deer Island. Since that time the pace of research and development has accelerated considerably, but in the minds of most people, has not even come close to meeting the needs of the industry.

To a large degree, this widening gap between the needs of the industry and adequacy of the research and development community, may be attributed to the scale on which events now occur. Specifically, the large numbers of fish currently in culture require services many orders of magnitude greater than those of even a few years ago. Consider, for instance, the great quantities of food which must be available to be fed to the fish 3-4 times per day, each day of the year. Salmon demand a high protein diet, which by definition implies a significant cost to the operation. As a result, there are currently research programmes being undertaken by some private sector operators, alone or in association with the Department of Fisheries and Oceans, which are attempting to identify more cost-effective diets and feeding methods than those presently used.

A major limiting factor to the expansion of the industry is the availability of smolt for the sea cage operators. Consequently, the private sector and government are engaged in capital programmes to increase the supply of smolt.

Monoculture of any species implies a greater opportunity for the incidence of disease. This appears to be especially true for salmonids. Although good husbandry practices are important in minimizing disease problems,

the industry must be able to cope with diseases as they will inevitably appear. Currently, the Department of Fisheries and Oceans disease diagnostic and research facility is located in Halifax, so that local contact with the industry is inadequate. The New Brunswick Department of Fisheries and Aquaculture provides some services also, but diagnosis is contracted to agencies outside the Province.

Currently, the only salmonid disease-related research programmes ongoing in New Brunswick are being carried out within the Department of Biology of the University of New Brunswick in Fredericton, and by the Food, Fisheries and Aquaculture Department of The Research Productivity Council. However, inadequate funding for programmes and facilities has been a limiting factor in the expansion of this area of research.

The area of culture gear is also receiving considerable attention with respect to research and development. In particular, with problems of storms, seals and the dwindling number of protected sites available, attention is now being focused on developing more durable and cost-effective cage systems. Much of this is in response to the arrival in New Brunswick of plastic and metal cages which have been imported from overseas. Already some New Brunswick companies are producing equivalent or better products locally. Specifically, one company at least, has engaged engineers to research the design for an improved locally-built cage.

7.2 SHELLFISH

7.2.1 Mussels

Compared to oysters, mussels have a relatively short history as a cultured species in New Brunswick. As such, they have an equally short history in terms of the research and development efforts applied to resolving culture problems. To-date only one species, the blue mussel (Mytilus edulis) is cultured and eaten in New Brunswick.

Funded by the New Brunswick Department of Fisheries and Aquaculture, Research and Productivity Council biologists initiated mussel culture research and development in the southeast region of the province in 1977. Initially demonstration suspension culture systems were deployed at selected sites near Shediac, Cocagne, Bouctouche, Richibucto, and Baie Ste. Anne. The objectives were to introduce the concept to local inhabitants, many of whom

had expressed interest in mussel culture, and at the same time establish base line information on spatfall conditions, mussel growth rates and the efficacy of various grow-out systems.

Most of the sites examined exhibited good potential in terms of spatfall and growth rates. As in Prince Edward Island, most of the mussel growing areas in New Brunswick are in shallow water which implies the need for special procedures to be implemented during the winter ice-cover period. One company in northeast New Brunswick initiated development of a land-based over-wintering system to provide easy access to its mussels.

Initial efforts involved the use of rafts, but most growers have now opted for the longline system. Various types of collectors and stocking mesh have been tested and continue to be tested as new materials arrive on the market.

In 1980, the programme was extended to the northeast part of the province in response to interest expressed by potential growers situated there. Culture systems continue to be tested and modified by growers in both areas of the east coast. Research and development in mussel culture has also extended to post-harvest activities. Various companies have experimented with existing processing machinery to declump, wash, and grade mussels for market and resetting.

In 1982 the Canada Department of Fisheries and Oceans provided funding for RPC and Fundy Isles Marine Ltd. to confirm the hypothesis that, despite the presence of Paralytic Shellfish Poisoning in the Bay of Fundy, with the use of the appropriate techniques it should be possible to develop a cultured mussel industry in these relatively ice-free waters.

The experimental work showed that by using suspension culture techniques, it is possible to harvest mussels from October to May without encountering significant levels of Paralytic Shellfish Poisoning in the meats. This corresponds with the time of year during which the highly toxic Gonyaulax excavata cysts occur as benthic organisms. Thus, so long as the waters of the culture site are sufficiently deep and protected, there should be little opportunity for the cysts to be carried up into the surface waters containing the cultured mussels. Moreover, the cold temperatures at this time of year imply a much reduced filtering rate by the mussels, so that the potential for ingestion of cysts is further reduced.

During the summer months, when the Gonyaulax is present in the upper portions of the water column in its motile phase, the mussels are involved in their reproductive stages during which time they are unsuitable for marketing.

On the strength of this research, the New Brunswick Department of Natural Resources and Energy, and the Department of Fisheries have initiated a programme to lease and develop selected areas within the southwest Bay of Fundy for the purpose of expanding New Brunswick's small mussel culture industry.

7.2.2 Oysters

American Oyster (Crassostrea virginica) cultivation, as practiced along the east coast, represents one of the province's oldest aquaculture endeavors. Although research and development activities of various kinds have been ongoing since the turn of the century, the disastrous "Malpeque Disease" which virtually wiped out the New Brunswick populations in the late 1950s, may be regarded as the point at which concerted research and development efforts were applied to oyster aquaculture.

Initial efforts were directed at re-seeding New Brunswick oyster beds with disease-resistant stock imported from Prince Edward Island. This met only partial success since seed importation alone was not sufficient to re-establish commercially viable stocks. Subsequently then, efforts were directed toward increasing the size of the critical mass necessary to establish self-sustaining populations which would permit a commercial harvest.

In New Brunswick, research and development efforts since that time could be considered as belonging in one or more of the following broad categories:

- Optimization of spat collection by using improved spat-collecting materials and techniques, and thus making available more seed to growers.

- Developing techniques and selecting sites to improve growth rates and thus reduce the time required to produce market size oysters.
- Developing techniques aimed at reducing the costly labour involvement in producing oysters.

With respect to spat collection, the industry has moved away from the expensive and inefficient scallop shell collectors to more modern materials including Chinese hats and French pipe. The latter has only recently appeared in New Brunswick and its efficacy has yet to be demonstrated.

Between 1976 and 1979, RPC undertook a series of studies investigating the opportunities and constraints associated with farming oysters in the southeast region of the province. The results are described in a series of reports available from the New Brunswick Department of Fisheries and Aquaculture. In essence, the studies demonstrated that some coastal sites were more conducive to enhanced growth than others, that oysters reared in floating trays for at least part of their life grew more rapidly, and that oysters grown from hatchery produced seed and reared in floating trays could be marketable in 4-5 years as opposed to 7-8 years for naturally produced oysters.

Oyster research and development suffered a serious set-back, beginning in about the middle 1970s, from which it has only recently begun to emerge. The set-back can be attributed to the well-meaning, but misguided attempts in Kent County to undertake rural development projects disguised as oyster culture ventures. These social development programmes were destined to failure, and when it inevitably came, it left an undeserved stigma attached to the business of oyster culture. Fortunately for the Province, separate initiatives were undertaken in northeast New Brunswick, particularly in Caraquet Bay, where research and development activities have resulted in the establishment of new oyster culture enterprises.

7.2.3 Clams

From an aquaculture perspective, little research has been undertaken on any of the hardshell or softshell clams in New Brunswick waters, although considerable efforts have been directed at various research and development aspects of wild stock populations.

The single exception concerns the 'quahaug' Venus mercenaria. In the Bay of Fundy, some attempts have been made at establishing self-sustaining populations of this non-indigenous species in Sam Orr Pond. To-date no commercial culture operation has yet been established

there. In 1983, preliminary experimental work was carried out on culturing quahaugs in Bouctouche Bay. Using seed purchased from Prince Edward Island, studies were undertaken comparing the growth rates of clams (1) held in floating trays, (2) placed on the bottom and (3) held in flow-through, on-shore trays. Maximum growth increases of only 4 mm over the course of a single, complete growing season discouraged the entrepreneur from pursuing any further efforts with this slow growing species.

7.2.4 Scallops

Preliminary work has been undertaken with two species of scallops in the waters of New Brunswick. In the Bay of Fundy, Dr. M. Dadswell, formerly with the Department of Fisheries and Oceans, has been investigating recruitment patterns, nutritional requirements, and growth rates of early stages of the giant sea scallop Placopecten magellanicus with a view to establishing the conditions which will be required for the successful culture of this species.

In the Gulf of St. Lawrence waters, there was rumoured to have been some preliminary experimental work on the bay scallop Aequipecten irradians, as an offshoot of work carried out by the Department of Fisheries and Oceans and the Prince Edward Island Department of Fisheries. However, the nature or location of this work has not been confirmed.

7.3 CRUSTACEANS

The only crustacean which has been the subject of aquaculture research and development in New Brunswick is the American lobster Homarus americanus. The work on this species has been carried out by Dr. D. Aiken's research group at the St. Andrews Biological Station and by Dr. A. Boghen at the Université de Moncton.

Dr. Aiken's work has been primarily directed toward understanding factors associated with reproduction and early life stages of the lobster. Although this has not as yet had a direct application to culturing lobsters commercially in New Brunswick, Dr. Aiken's work has been important in the technical developments associated with experimental lobster culture in P.E.I.

Dr. Boghen (in collaboration with Dr. J. Castell of DFO, Halifax) has directed his studies toward determining nutritional requirements of lobsters. Again, this has not yet played a significant role in New Brunswick aquaculture. However, diet formulation will be an obvious consideration when commercial lobster culture becomes established.

7.4 SEAWEEDS

Although commercially important red seaweeds, such as Irish Moss (Chondrus crispus) and dulse (Palmaria palmata) are harvested in the wild from New Brunswick waters, there are no commercial seaweed operations in existence in the Province. Genu Products at one time considered undertaking some research and development at its plant in Pointe Sapin, but nothing appears to have come of that initiative.

8. EDUCATION AND TRAINING

Education and training in aquaculture can be subdivided into academic (university) and technical (community colleges and other technical institutions). Following is an overview of academic and technical training available in New Brunswick and, in more general terms, in the Atlantic provinces.

8.1 ACADEMIC EDUCATION

Institutions providing academic education in areas relating to the aquaculture industry have been relatively slow to respond to the need to train students for the industry. There are several specific programs identified for aquaculture, in New Brunswick universities, and other universities in the Atlantic Provinces. Specialization in aquaculture per se, a very diverse, multidisciplinary subject, is not always appropriate at the undergraduate level. However, students enrolled in marine biology programs, which are offered by a number of Atlantic province universities, may specialize, especially at the Honours level, by taking combinations of courses in which some of the essential theoretical and practical background in areas relating to aquaculture could be attained.

Within the Province of New Brunswick there are three universities with biology departments: the Université de Moncton; Mount Allison University; and the University of New Brunswick which has two campuses, one in Fredericton and one in Saint John. Although there are a number of courses with some aquaculture content in all departments, the department of biology at UNB Fredericton is the only one that has developed a specific undergraduate program in aquaculture. With the loss through retirement of the co-ordinator and principal faculty member in charge, this program is now in jeopardy. The continued development of a Co-op program at UNBF which will include the placing of students interested in aquaculture in government labs or in private aquaculture operations, will further contribute to serving the needs of the industry in the future by providing highly-qualified graduates with on-the-job training.

Educational contributions have been made by the Université de Moncton where, in 1985, an introductory course (Biology 3544-Aquaculture) was offered by Dr. A.Boghen. In addition, a new undergraduate course, which will discuss aquaculture as a

specific component of coastal studies, is under consideration for introduction in the near future. Both Dr. Boghen, whose interests also encompass parasitology, shellfish nutrition and behaviour, and Dr. P. Beninger, whose interests encompass molluscan and crustacean biology, have some interest and expertise in aquaculture and supervise graduate students with similar interests.

Mount Allison University, although lacking aquaculture recourses per se, provides a broad background in biology which enables students to develop aquaculture interests at the graduate level elsewhere.

8.2 TECHNICAL TRAINING

Technical training in aquaculture in New Brunswick has a strong track record. For the past ten years the Huntsman Marine Science Centre, in collaboration with the N.B. Community College (St. Andrews campus) and the Canada Employment and Immigration Commission (C.E.I.C.), has offered a very successful Aquaculture Technician Training Program (A.T.T.P.). The A.T.T.P. program was a first-of-its-kind in Canada, and the majority of the more than 100 graduates have found positions in the aquaculture industry, both local and elsewhere. The A.T.T.P. has suffered to some extent in that the Huntsman has at times had little influence on the selection of students for the course. The A.T.T.P. entrants are usually a mix of recent high school graduates, some university graduates, and mature individuals with existing industry experience. The Huntsman has also been active in promoting and conducting training programs such as the Aquaculture Worker program, and specific training programs in aquaculture for native peoples. These shorter courses have much less content and training than the A.T.T.P. program, but are designed to give specific training to those already in the industry, or planning to set up aquaculture projects (such as the native people). Also, the Huntsman has played a major role in coordinating aquaculture workshops, and organizing tours of Norwegian aquaculture facilities, on behalf of the industry.

The School of Fisheries in Caraquet offers an oyster and mussel course - "Oysters since 1979".

In summary, institutions of higher education, while they have responded to the need to produce undergraduate or graduate students with specific qualifications in aquaculture, have not yet been able to keep up with the demand for qualified graduates. This is not a typical, especially when the response is to a fast-growing industry. Universities are not especially designed, nor intended, as training grounds for specific industries; only in the more modern context of Professional Schools is this a declared goal. For the future, the industry may have to continue to depend on students with rather general backgrounds in the life sciences, and will need to shoulder the onus of training the right individuals in the specific needs of the industry.

The universities should be encouraged, however, to introduce more courses of benefit to the aquaculture industry (such as the Huntsman course), and to facilitate the conduct of post-graduate, graduate, and faculty research in aquaculture. Wherever this can involve direct or indirect industry and government participation, this should be encouraged.

Technical training is proceeding at a rate not close to saturation in the more general aspects. There is a need in the future to develop short technical courses on special topics, or upgrading courses, to enable workers in the industry to keep abreast of the latest technical and scientific information.

9. MAJOR CONSTRAINTS/OPPORTUNITIES

9.1 FINFISH

The following critical areas warrant research and development work in the finfish sector.

DISEASE:

Although furunculosis is no longer the devastating threat it once was, this disease is still important and must be contained, which requires ongoing research. The problems of Bacterial Kidney Disease (BKD) and Bacterial Gill Disease (BGD) are poorly understood at present and clearly require much more research into immunological possibilities and ways of prevention. Among crustacean parasites, both Salmincola (in fresh water) and Lepeophtheirus ("sea lice") represent significant problems to the aquaculture industry with loss of fish. Of particular importance is the potential role these (and other ectoparasites) may play in the transmission of pathogenic bacteria and viruses. Any research in this area would be useful and could be valuable to the industry. The significant economic losses to the traditional fisheries industry, which have been increasing in recent years (and which continue to increase), due to heavy infection of fish with anisakine nematodes, could become a threat to sea-ranched salmonids. An active research program in this area is presently in place at the University of New Brunswick in Fredericton and should be encouraged to develop strategies aimed at helping the aquaculture industry.

While great benefit has been derived in the past from the excellent diagnostic services provided by the Federal Government (DFO) laboratory in Halifax, with the present growth of the aquaculture industry in New Brunswick, it is essential that a closer, hence faster, service be developed in New Brunswick. With the research infrastructure in place within universities and RPC, it would seem logical for the Provincial service to develop in close association and collaboration with these existing facilities.

FOULING:

The fouling of gear is a major concern for farmers from sanitation, health and husbandry points of view. A net treatment which would slow the growth of sea life on cage nets and associated equipment would be a welcome product/technology.

FEED NUTRITION:

The growers must be assured of a quality formula for fish food to attain maximum growth and health. Much is yet to be learned about all feed types from moist to dry.

Feed & nutrition are very important for finfish. Probably the monitoring of the quality of raw materials and final product might be more important than developing new diets since private companies will provide these. Improving the quality and consistency of raw products will provide an excellent base for any fish food.

POACHING:

Security equipment for cage sites will become a reality as the value of crops increase. Much design work remains to be done with site security systems.

NEW SPECIES:

Research and development is required into the potential for culturing alternative species (i.e. cod, halibut, etc.). We would like to see the existing work being done on new species accelerated, and the results shared with the industry as a whole.

The main emphasis should be on improving the raising of existing species but some funding should be allocated to new species development. New species development is a long term project and we should especially look at species which can be reared in areas now not suitable for salmon.

SUPERCHILL:

This is one of the main physical threats to our fish. Research, currently underway should be encouraged to continue. Given the time it will take for this characteristic to express itself, long term research and development funding is required.

PREDATORS:

Warning devices to ward off bird and seal predators is technology needed for long term success.

STORMS:

a) Sea breaks developed to reduce the risk to sites (i.e. ice build up and large seas).
b) Cage designs to be used in more open and exposed areas of the Bay of Fundy.
c) Mooring systems could be improved with some research.

EDUCATION:

Our current programs are not meeting the demands of the industry. We need more programs in our universities and colleges.

MARKETING:

An industry-wide generic advertising campaign, similar to the agriculture sector is needed for aquaculture. This, coupled with a professional quality control program, is an area requiring much development.

GENETICS:

A broodstock management program to guarantee the long term survival of the industry must be developed in the immediate future.

ENVIRONMENT:

This will be very important in the future. A monitoring system should be set up immediately to assess most aspects of the water environment to determine pollution control limits. With this in mind we should remember that the best bioassay for any site is the fish on it.

9.2 SHELLFISH

9.2.1 Mussels

Of great concern, and even some alarm, is the recent problem concerning toxins in edible mussels from Prince Edward Island. That there was no research infrastructure in place to provide even a background of information against which the problematic mussels could be compared, underlines the potential plight of the shellfish industry. This industry suffered enormous losses in the past due to "Malpeque Disease" of oysters, has suffered recently from the toxic mussel scare, and will continue to be vulnerable unless a research unit is supported to work on shellfish diseases.

FINANCING:

Financing is considered to be one of the industry's major problems, if not the main one.

A lack of confidence on the part of banking establishments causes them to ask the producers for guarantees, there by making this type of financing next to impossible.

In New Brunswick, the Fisheries Development Board can help producers finance their needs.

It should be noted that the capital invested yields no return for two years, and then only if no problems arise along the way. The break-even point can vary from one producer to another, depending on the scale of production. The smaller producers, relatively unmechanized, talk about 27,000 kg (60,000 lb), while others who are larger and more mechanized are thinking about a minimum of 180,000 kg (400,000 lb/year).

MARKETING:

The Government of New Brunswick will have to continue to assist in promoting N.B. mussels both inside and outside the province by means of promotional documents designed to make consumers and potential buyers aware of the existence of high-quality cultivated mussels in the province.

The Canadian mussel industry is young, and since the markets are not yet saturated, it is very important to offer a high quality product in order to secure a market share.

MARKETS AND PRICES:

The Montreal and Toronto markets are the largest in Canada. They used to be supplied by Belgium and the United States (Maine), but during the past few years, Prince Edward Island mussels have captured a very large share. Wholesalers require weekly or bi-weekly deliveries, which can cause problems for small producers. As a result, it is important for the producers to join together in order to provide a continuous supply and obtain adequate prices.

MATERIAL RESOURCES:

It is preferable for a company to have one or more buildings for equipment storage and repair and for carrying out the different mussel culture operations (from harvest of the spat to marketing).

The building used for the mussel handling operations normally houses the following equipment: a socking table and a declumper-grader made of stainless steel or aluminum and tanks supplied with salt water where mussels can be preserved for short periods. The approximate cost of the sock manufacturing machine is $900; the declumper-grader for seed mussels costs $3,000, and the declumper for market mussels, $10,000. In addition, companies must have one or more vessels adapted to the needs of mussel culture and a truck.

One Prince Edward Island company has an airboat which it uses mainly during the sock harvest in the fall and spring when ice prevents the use of boats or trucks.

It is also essential to have scuba diving equipment, as this greatly facilitates supervision of the submerged equipment and the production.

HUMAN RESOURCES:

This factor varies first of all in accordance with the size of the operation, but also with the type of operation (its degree of modernization).

For example, an operation producing 10,400 kg (23,000 lb) will employ two person-years, broken down as follows: six employees during two months in the spring and two months in the fall.

ORGANIZATION OF THE INDUSTRY:

A constraint of the mussel farmers has been a lack of collaboration.

Such collaboration can take various forms, including exchanges of ideas; pooling of the more costly machinery; purchases of equipment such as buoys, ropes, etc., in order to obtain better prices; establishment of a plant to facilitate marketing the product.

9.2.2 Oysters

NEW SPECIES:

The "Malpeque" oyster grown along the east coast of the province takes five to six years to reach market size, but their quality is worth it. The European oyster is unsuitable for the east coast, but would do well in the Bay of Fundy.

FEED AND NUTRITION:

There is a need for research on the fluctuation of natural nutrition and its effects on the growth and mortality rate of the oysters.

DISEASE:

Under present conditions, there is little in the way of proactive research undertaken with respect to shellfish diseases. Rather, the tradition has been to marshall the available forces at the onset of a particular problem. The recent (December, 1987) problems of toxicity in Prince Edward Island mussels is a particularly cogent example of this traditional approach. The group has identified the need for immediate development of a program to investigate shellfish disease issues in New Brunswick.

AQUACULTURE ENGINEERING:

a) Biological - It would be desirable from an economic perspective to increase the growth rate of our oysters. Some solutions toward that goal may be found in a better understanding in the biology of our oysters, particularly in the form of genetics.

b) Physical & Mechanical - Better equipment is necessary to increase profitability. Also new equipment and tools could start the exportation of new technologies to other oyster producers elsewhere in Canada and other countries.

EDUCATION AND TRAINING:

With the planned advances in technology anticipated for introduction to the industry, there will be a need also for new entrants into the industry who have a stronger background in technology, especially as it applies to the business of growing oysters. The industry sees the combination of this type of background with hands-on practical experience as a prerequisite for successful human resource development in the industry.

COMMUNICATION:

Currently there is a lack of productive communication amongst oyster farmers in New Brunswick. Accordingly there is no strongly motivated focus group around which the industry can develop. There is an apparent attitude of distrust amongst oystermen which has prevented the development of a much needed focus group. The industry recognizes the need for a program directed at changing existing attitudes in an attempt to improve the development of communications. A program of workshops and seminars at which industry, government, researchers and other specialists in finance and marketing participated is viewed by the industry as an important component in such a program.

PROCESSING:

Prior to the implementation of more rigorous fish processing regulations by Department of Fisheries and Oceans in 1987, oyster processing was undertaken in a variety of conditions. The industry sees the need to work with Department of Fisheries and Oceans' inspection staff in adjusting the regulations to cover the special needs of the oyster industry.

ENVIRONMENTAL CONCERNS:

For several years now, oystermen have witnessed unexplained "die-offs" of oysters in a number of growing areas within the province. With no environmental monitoring program in place, biologists have little or no solid scientific information on which to attribute causes, and more importantly to recommend remedial action. Moreover, in many instances by the time the die-off is noticed, it is already too late to effect any remedial measures. The Group recognizes the need for a more intensive program of shellfish habitat monitoring and management.

STOCK SUPPLIES:

Because the collection of naturally produced spat is strongly influenced by climatic and other environmental factors, over the years there have been frequent instances of spatfall failure. This has been especially true of the situation during the last two years. This recruitment failure translates into the absence of

virtually whole year classes of marketable oysters some 5-7 years following the spatfall period. It is critical to the development of the oyster industry that a strategy be developed which will ensure a regular supply of spat to the province's oystermen. The group views the development of a hatchery as a key component of this strategy.

EQUIPMENT:

Many oyster farmers continue to use outdated equipment such as the long scow and oyster rake. There is a strong need to develop new farming technology and tools which will obviate the need for these outdated and inefficient relics from the past.

9.3 GENERAL

NEW SPECIES:

Monocultures of any kind are potentially at great risk. With the reality of a small geographic area in which to farm, the salvation of the area could be in polyculture. With monoculture, any detrimental effect on one site could negatively impact upon all sites.

It makes every good sense to develop new species; to develop mixed cultures where one organism actually benefits from the presence of another. Although the potential for new species in aquaculture may seem limited, we believe it is extremely high and that the prospects are excellent. However, this must be tied into some research and development as well as marketing strategies.

FOOD AND NUTRITION:

Although a significant research contribution has been made in identifying the ideal components of food for optimum yield in salmonids, we are still in the early stages of development and further research and development is required for salmon and other species.

DISEASE:

It is essential that some group(s) is/are continually working on diseases of various types: bacterial, viral, fungal and parasitic. It is only by encouraging continued research in fish diseases that the expertise may be readily available to advise on protocol when serious problems do arise. In addition, conditions which prevail here are often different from these found elsewhere and hence the importance of maintaining local experts.

EDUCATION AND TRAINING:

Clearly, this is essential especially if there are going to be any "new players". The potential loss of the UNB Aquaculture option in a B.Sc. Biology Program could be prevented with the appointment of one or two "Chairs" in Aquaculture. Perhaps one in Fredericton and one in Saint John could support the two, present major thrusts: salmonid aquaculture and shellfish aquaculture. Support of such applications for Chairs by the Industry could be critical to their being funded; such Chairs would provide not only the educational base for an improved University degree specializing in aquaculture, but would also provide some real research expertise which, in turn, would meet some of the objectives indicated above.

Together with the new Co-op Program being developed by the Biology Department at UNB in Fredericton, the industry would be well-served in future years.

COMMUNICATION:

Increased awareness of all the different aspects of aquaculture is critical and an extension program, would greatly enhance aquaculture in the province.

MARKETING AND PROCESSING:

Clearly there is a great need here, particularly with reference to "creating demands" for new species. The industry must work closely with government on this to their mutual advantage.

GENETICS:

Finding new hybrids or selecting for specific traits can be extremely useful in producing bigger organisms more efficiently. However, great care must be taken in making sure that "good genes" (e.g. for disease resistance) are not bred out. Some exciting work is now going on with gene manipulations and if this can be applied to disease resistance or other useful characters, it may be able to obviate the long term studies using conventional, "classical" approaches.

CURRENT IMPEDIMENTS OF COMMERCIALIZATION:

Eight major impediments of adoption and commercialization of new and best practice technologies by the aquaculture sector are recognized:

i) There is generally a poor level of knowledge on existing or new technologies, and about aquaculture as a whole. There is a definite need for an improved network for the gathering and dissemination of technological information to the industry, especially in view of the rapid growth of aquaculture in New Brunswick.

ii) Following from i), there is a lack of coordination of resources and programs between government, industry and educational institutions to meet the priority opportunities for aquaculture development in New Brunswick.

iii) The aquaculture industry is dependent on front-end financing; it is regarded as a high risk industry and not overly attractive to investors. A strong and directed research and development activity will greatly reduce the actual and perceived risks associated with aquaculture operations.

iv) In the past, the aquaculture industry has not received the commitment from all levels of government (eg. lack of legislative authority and regulations; lack of coordination in regulation of the industry; lack of adequate information exchange between federal and provincial governments and the industry).

v) A coordinating body for New Brunswick aquaculture research and development is currently lacking.

vi) Aquaculture is new and in competition for funding directed toward the traditional fishery, and therefore has not received the level of government attention and support that it requires at this critical stage of development.

vii) There is a lack of available funding for the support of post-graduate student research on targeted aquaculture projects.

10. RECOMMENDATIONS

STATEMENT OF PRIORITIZATION

The following recommendations for finfish and shellfish are all priority items. To direct the reader with interpretation we provide the following priority index:

A = HIGH
B = MEDIUM
C = LOW

10.1 Finfish

PRIORITY INDEX

10.1.1 Disease:

A **The Task Group recommends the establishment of long and short term programs to address bacterial, viral and parasitological diseases in farmed Atlantic finfish.**

At present, Bacterial Kidney Disease (BKD) is the principal threat. The future no doubt will bring XYZ and other yet-to-be-experienced diseases. For this reason, research and funding for research should be many-fold. Firstly, we need to see now the establishment of a long-term research program which will operate with continuity on the fringe of the industry. This will provide research into the various bacterial, viral, and parasitological problems that exist now and will exist in the future. The program can, and should be, established using existing facilities and we believe is best conducted and supported at the university level.

Secondly, the aquaculture industry needs a monitoring program to attend to the immediate needs of prevention and to advise on the control of individual outbreaks. Again, the Task Group believes this can be accomplished by funding programs at existing facilities in the province.

Thirdly, re: disease issues and happenings, were commend funding to support efficient communications so that the issue of disease treatment drugs and their time of use and withdrawal be addressed, and guidelines for their use be established. Coupled with this, we must review with the aim of certifying skin and colouring agents, particularly for export markets. The funding for this can be directed toward there commendation for an extension service.

PRIORITY INDEX

And finally, both the long and short-term research and development work being recommended under the heading of Disease will contribute significantly to our better understanding and first-hand knowledge of any environmental impacts that may result.

10.1.2 Feed and Nutrition:

A **The Task Group recommends long term research be supported for finfish diets, feeds and feed formulae to provide the industry with the best available products and advice.**

The single most important parameter affecting the overall health and growth of the fish is the feed and ingredients of the food. There are differing schools of thought on wet feed vs. dry feed, and the correct or right feed is really a matter of the individual farmer's preference.

Much work has been done since the late 1960's on salmon feeds, though most of this is specific to European stocks and European sites.

It is recommended that the New Brunswick industry review the past developments in Europe. If a full literature review has not been completed for the feed sector, then funding should immediately be provided for this exercise. With this complete, we can then compare the experience of the past ten years in New Brunswick.

No doubt there will be similarities from which we should learn and differences to which we should direct our research and development. Naturally, due to farming different stocks in a different geographical area, our feed and nutrition needs will not be the same as our European cousins.

Our research effort should start with the basic raw material, whether it be herring, capeline, or squid. We should look at not only the suitability of the material, but also the availability of these species as most are cyclical.

The Task Group also recommends reviewing formulations which are not dependant upon cyclical fisheries. With the increasing growth of world finfish aquaculture there may be a short supply of available herring, capeline and squid for fish feeds.

10.1.3 Genetics:

PRIORITY INDEX

A **The Task Group recommends the establishment of a broodstock genetics program to enhance our abilities to raise healthier, stronger and more ideal aquaculture stocks.**

The industry is at present obtaining most of its raw material from its own aquaculture stocks. We do not have an existing program which is monitoring in-breeding, grilse percent or broodstock selection of any kind. We believe a program should be started immediately.

From a biological engineering point of view, were commend additional funding be available to support a long term genetics/breeding program to provide for healthier, dedicated aquaculture stocks. The program should take into account the disease and water temperature restrictions of our area, coupled with the market demands re: physical shape and appearance of the fish.

10.1.4 Engineering:

B **The Task Group recommends research and development into ongoing design review so that improvements can be made to cage systems, mooring systems, and automatic feeding and security systems.**

With the growth of the industry, we should expect to see new developments in the processing technologies and funding should be made available for experimentation with such items as the vacuum system for gutting fresh salmon.

10.1.5 Environmental:

A **The Task Group recommends a combined program of government and industry to develop a better understanding of our finfish growing waters.**

We need to develop a better understanding of the relationship between environmental quality and its effects on the growth, health and overall condition of our fish crops, and the inter relationships with other resource users.

10.1.6 New Species:

PRIORITY INDEX

C **The Task Group recommends that some priority be attached to the prospect of culturing additional commercially valuable species.**

10.2 Shellfish

10.2.1 Shellfish Hatchery

A **It is recommended that to accelerate the development of the technology required to benefit the shellfish industry in New Brunswick, an industry - research - government Group Sub-Committee be formed to consider the establishment of a shellfish hatchery suitable to the needs of the Province.** In addition, this group would be charged with preparing and implementing a plan which would see expanded efforts directed towards relevant research and development topics involving molluscan shellfish currently being cultured in New Brunswick. A second feature of the plan would be the development of a program of research and development leading to the commercial culture of additional shellfish species such as the European oyster, the giant sea scallop and others from which economic benefits may be derived.

The Task Group recognizes that New Brunswick lags behind other Atlantic Provinces in terms of its contributions to the research and development needs of the shellfish industry. One of the major contributing factors to this situation has been identified as the absence of a shellfish hatchery facility in the province which is needed to catalyze research and development in this sector of the aquaculture industry.

10.2.2 Health and Disease

A **The Task Group recommends the establishment of a program to address the short term and the long term issues concerning the incidence of diseases in farmed Atlantic shellfish.** One aspect of this program would include a rigorous disease monitoring and inspection system, to be structured as a cooperative venture between industry and government.

PRIORITY INDEX

The autumn and winter of 1987-88 will not be soon forgotten by shellfish farmers because of the appearance of life-threatening toxins in mussels and oysters from Prince Edward Island.

Some, at least, of this can be directly attributable to the absence of a meaningful research and development program directed towards identifying causes and controls for diseases experienced by shellfish in general, and for other health related issues which are of a greater concern to consumers.

10.2.3 Culture System Development

A **The Task Group has identified the need for a comprehensive program to address the appropriate biological and engineering needs in culture system development through consideration of the following recommendations:**

Oysters

- **Development of the technological capability to permit establishment of at least two seed production units with a combined annual output of 12 million seed.**

- **To accelerate development of the technology required to increase the seed collection efficiency in the province. More specifically, there is a strong need for comprehensive research and development programs directed at developing and implementing new materials and methods to maximize the potential offered by productive seed producing areas in New Brunswick.**

- **To formulate a development plan which would be directed at optimising the potential of existing public oyster beds.**

- **To develop mechanisms for assisting industry in improving their capabilities with respect to spatfall prediction and spat collection.**

- **Development of an industry - research - government oyster liaison group to provide guidance to development of the industry in New Brunswick, and to serve as a focal point for organizing inter-provincial and international information exchange forums.**

PRIORITY INDEX

- Increase the frequency, course content and intensity of cultured oyster training programs currently being delivered by the New Brunswick Department of Fisheries and Aquaculture.

- To continue programs directed at the development, construction and testing of innovative oyster growing equipment.

Mussels

- Formulate a program which would be directed towards accelerating the development of the technology required to increase the production and efficiency of New Brunswick mussel growers. Specific attention should be given to developing and funding the appropriate mechanisms which would provide industry with access to the technological specialists who could assist them in increasing their self-sufficiency and maximize the potential benefits from their operations.

- Development of an industry - research - government mussel liaison group to provide guidance to development of the industry in New Brunswick, and to serve as a focal point for organizing inter-provincial and international information exchange forums.

- Increase the frequency, course content, and intensity of training programs currently being delivered by the New Brunswick Department of Fisheries and Aquaculture.

- Encourage and foster the establishment of co-operative processing plants which could serve growers in the various regions of the province, as production volumes begin to warrant.

- Increase emphasis on the development of value-added processed products from cultured mussels. Specifically, there is a need to develop smoked and marinated products to displace those products currently being imported to Canada from Spain and Scandinavia.

PRIORITY INDEX

10.2.4 Environmental Concerns

A **The Task Group recommends the establishment of a program whose objective would be to combine the efforts of government and industry in improving the quality of shellfish growing waters, and developing a better understanding of the relationships between environmental quality and the incidence of shellfish diseases.**

Shellfish farmers have been expressing increasing concerns regarding the quality of the environment surrounding their operations. In addition to the on-going problems of faecal coliform contamination of shellfish beds, concerns are also now being expressed over mysterious "die-offs" which have occurred in the province. In particular growers are concerned about the relationships between environmental quality and the incidence of disease.

10.2.5 New Species

B **It is recommended that some priority be attached to the prospect of culturing additional commercially valuable species when considering program development for the proposed shellfish hatchery, especially in view of the downstream benefits which could accrue to the industry.**

The Task Group recognizes that there is demonstrated potential for New Brunswick's shellfish farmers to diversify their operations by culturing additional valuable species such as the giant sea scallop, the European oyster, hard shell and soft shell clams, as well as others not yet identified.

10.3 General Recommendations

10.3.1 Aquaculture Council

A **The Task Group recommends the establishment of an Aquaculture Council to advise industry, government, and research and development interests in the future development of aquaculture in New Brunswick.**

PRIORITY INDEX

Task Group members have concluded that information transfer amongst the various participants in aquaculture development in the Province is inadequate to meet the needs of a growing industry. Members agree that the Province in general, and the industry in particular, would benefit from the establishment of such a Council to serve in an advisory role to development of the industry. The Council would comprise representatives from industry (finfish and shellfish), federal and provincial governments, universities, and research and development institutions who can provide the necessary technical input to strengthen the industry.

The Council would also serve as a forum through which broader issues, such as leasing policy, environmental concerns, health and disease issues, etc., could be debated to arrive at a strong consensus on the appropriate sections to be taken.

10.3.2 Extension Service

A **The Task Group recommends that one of the first priorities addressed by the Council should be to identify, prioritize and program topics to be included in an Aquaculture Extension Service.**

The need for an Extension Service has been given a high priority by the Task Group. Communication links amongst industry, government, and research and development institutions must be strengthened to meet the increasing demands by the growers for the latest information as soon as it becomes available. This is viewed as being critical if New Brunswick growers are to maintain and increase their market positions in a very competitive environment.

The Task Group has identified a broad range of technical expertise currently existing amongst government, university and research and development institutions in the province. Moreover, with several years of experience gained by the growers themselves, they are considered to be a strong technical resource for demonstrating future developments in the industry.

The Task Group recognizes a strong need for the province's expertise to be focused, augmented by outside expertise where necessary, and directed towards solving technical problems faced by the industry.

PRIORITY INDEX

It is envisaged that no additional infrastructures are required to launch and maintain the Extension Service. Rather, the Task Group believes that existing physical plant resources in the province, if complemented by funding to support human resource and program operating needs, will be adequate at least over the short term duration.

10.3.3. Inter-Governmental Affairs

A **It is recommended that the appointed representatives of the Government of Canada and the Province of New Brunswick resolve to settle all outstanding jurisdictional issues which impact on the development of the aquaculture industry in New Brunswick.**

The industry frequently finds itself entangled in jurisdictional differences which have not yet been resolved between the provincial and federal governments. The lack of clear definition on such issues as environmental parameters, stock control, permits and health issues urgently needs to be rectified to ensure timely and orderly development of the industry.

10.3.4 Marketing

A **The Task Group recommends that funding be available for the immediate development of a generic marketing campaign to promote New Brunswick grown aquaculture products.**

The aquaculture industry in New Brunswick is establishing an excellent reputation for premium products. Now is the time to build upon this base and establish market presence and share. We believe a professional media campaign can achieve this.

10.3.5 Education and Training

B **1. The Task Group recommends that support and encouragement be given to graduate students, interested in working on any aspect of aquaculture, at the M.Sc.and Ph.D. level.**

PRIORITY INDEX

While some areas are seen as high priority areas at present (e.g. salmonid diseases, shellfish pathogens and toxins) many future problems may be obviated if research can be started now (e.g. potential parasitic problems with anisakine nematodes). The development of new areas for aquaculture could be investigated through graduate student research (e.g. scallops, shrimps, seaweeds) as could novel approaches to polyculture (e.g. growth of filter-feeders, such as shellfish, and seaweeds in close association with finfish cages).

B **2. The Task Group recommends that the development of aquaculture programs at the undergraduate level be supported.**

Of special note here is the new Coop Program at the B.Sc. (Biology) degree level at UNB in Fredericton. Students enrolled in such a program, and who spend three "terms" working with an aquaculture operation, would be invaluable to the industry and its development in the years to come.

B **3. The Task Group recommends that the technical training program of the N.B. Community College continue to be supported in St. Andrews, in collaboration, with the Huntsman Marine Science Centre, and that other courses in aquaculture, such as these offered by the School of Fisheries in Caraquet also be supported.**

It is through these technical training programs that the Aquaculture Industry will find many of the specially-trained workers who will be needed in the anticipated expansion of existing, and new aquaculture operations.

B **4. The Task Group recommends that consideration should be given to continue supporting novel educational initiatives that would benefit the existing industry.**

The provision for example, of continuing short, intensive workshop programs, relating to different aspects of aquaculture, could be of great benefit to those working in aquaculture operations particularly as new information becomes available. The possibility of funding visiting speakers to participate in such workshops should also be continued.

11. APPENDIX

11.1 Task Group Members

Brian Rogers (Chairman)	Sea Farm Canada Inc.
John Malloch	Harbour de Loutre Products
Cecile Lanteigne	Le Moule Bleu
Garnet Matheson	Aqua Ventures Ltd.
Chris Frantsi	Connors Bros. Limited
John L'Aventure	Fundy Aquaculture Ltd.
Serges Dugas	Caraquet Aquaculture Ltd.
Robin South	Huntsman Marine Science Centre
Bev Bacon	Research & Productivity
Kerry Wilson	Dept. of Fisheries and Aquaculture
Ray Gallant/Maurice Mallet	Dept. of Fisheries & Oceans
Michael Burt	University of New Brunswick
Gilles Surrette	Fish Farmer-Bouctouche